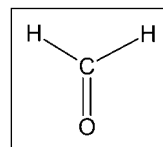


41. Formaldehyde

CHEMICAL NAME = methanal
CAS NUMBER = 50-00-0
MOLECULAR FORMULA = CH₂O
MOLAR MASS = 30.0 g/mol
COMPOSITION = C(40.0%) H(6.7%) O(53.3%)
BOILING POINT = -19.3°C
MELTING POINT = -117°C
DENSITY = 1.38 g/L (vapor density = 1.07, air =1)



Formaldehyde is a colorless, flammable gas with a distinctive pungent odor. It is the simplest aldehyde, which is a class of organic compounds with the carbonyl group bonded to at least one hydrogen atom. Formaldehyde was described by August Wilhelm von Hoffmann (1818–1892) in 1867 after the Russian Aleksandr Butlerov (1828–1886) had inadvertently synthesized it in 1857. Formaldehyde readily dissolves in water to produce a solution called formalin, which is commonly marketed as a 37% solution.

Formaldehyde is a by-product of combustion of organic compounds, metabolism, and other natural processes. Formaldehyde results from wood combustion and elevated atmospheric concentrations can result from forest fires, as well as from urban pollution sources such as transportation. Formaldehyde has been identified as a significant indoor air pollutant. Building materials such as particleboard, plywood, and paneling are major sources of formaldehyde because they incorporate formaldehyde resins as bonding adhesives. Other sources of formaldehyde in the home are carpets, upholstery, drapes, tobacco smoke, and indoor combustion products. Formaldehyde may be emitted from building materials for several years after installation. In the two decades of the 1960s and 1970s, a half million homes in the United States used urea formaldehyde foam insulation, but health complaints led to its elimination as an insulator in the early 1980s. People react differently to formaldehyde exposure, but it is estimated that between 10% and 20% of the population will experience some reaction at concentrations as low as 0.2 parts per million. Formaldehyde irritates the eyes, nose, and throats, producing coughing, sneezing, runny nose, and burning eyes. More severe reactions result in

insomnia, headaches, rashes, and breathing difficulties. Some states have established indoor air quality standards ranging from 0.05 to 0.5 ppm.

The industrial preparation of formaldehyde has occurred since the late 1800s and involves the catalytic oxidation of methanol: $2\text{CH}_3\text{OH}_{(g)} + \text{O}_{2(g)} \rightarrow 2\text{CH}_2\text{O}_{(g)}$. The oxidation takes place at temperatures between 400°C and 700°C in the presence of metal catalysts. Metals include silver, copper, molybdenum, platinum, and alloys of these metals. Formaldehyde is commonly used as an aqueous solution called formalin. Commercial formalin solutions vary between 37% and 50% formaldehyde. When formalin is prepared, it must be heated and a methanol must be added to prevent polymerization; the final formalin solution contains between 5% and 15% alcohol.

Formaldehyde has hundreds of uses. Its largest use is in the production of synthetic resins. Many formaldehyde resins are hard plastics used in molding and laminates. Formaldehyde resins are used to treat textiles to make them “wrinkle-free.” It is also used to produce adhesives, which are used extensively in the production of plywood and particleboard. Other common uses are as disinfectants, fungicides, and preservatives. Formalin has been the traditional embalming fluid used in the mortuary industry for the last century. Formaldehyde is also used in papermaking, textile production, and fertilizers.

More than half of the commercial formaldehyde produced is used to manufacture phenolic, urea, and melamine formaldehyde resins. Polyacetyl resins use another 5–10% of formaldehyde, and approximately 80% of formaldehyde goes into the resins and plastics industry. Phenolic-formaldehyde resins were the first synthetic plastics to be produced. The first plastic was called Bakelite. Bakelite was produced in 1906 by the Belgian-born (he immigrated to the United States in 1889) chemist Leo Hendrik Baekeland (1863–1944). Baekeland made a small fortune selling photographic paper to George Eastman (1854–1932). Using this money, Baekeland studied resins produced from formaldehyde and phenol by placing these materials in an autoclave and subjecting them to heat and pressure. Bakelite was a thermosetting phenol plastic. A thermosetting plastic hardens into its final shape upon heating. Engineers at Westinghouse used Bakelite to treat paper and canvas and compress the mixture into hard sheets to produce the first laminates. These were initially used as electrical insulators, but two of the engineers, Herbert Faber (1883–1956) and Daniel O’Conor (1882–1968), used the process to establish the Formica Corporation. The word *formica* was derived from the fact that mica was used as a common electrical insulator in the early 20th century, and the new resin could substitute “for mica.”

Formaldehyde has traditionally been used as a preservative in biology and medical laboratories and in embalming fluid. Embalming fluids typically contain 5–15% formaldehyde, a significant percentage of alcohol, and other additives to perform certain functions, for example, bleaches and coloring to preserve skin color. Formaldehyde has been used to preserve dead bodies since 1900 and has several qualities that make it the preferred preservative. Foremost among these is its low cost, but it also has several biochemical advantages: it kills germs and microorganisms, destroys decomposition enzymes, retards decomposition of proteins, and hardens body tissues.